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Surgeon-Performed Ultrasound for the Assessment of Truncal Injuries

Lessons Learned From 1540 Patients

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Objective

To determine the accuracy of the Focused Assessment for the Sonographic examination of the Trauma patient (FAST) when performed by trauma team members during a 3-year period, and to determine the clinical conditions in which the FAST is most accurate in the assessment of injured patients.

Summary Background Data

The FAST is a rapid test that sequentially surveys the pericardial region for hemopericardium and then the right and left upper quadrants and pelvis for hemoperitoneum in patients with potential truncal injuries. The clinical conditions in which the FAST is most accurate in the assessment of injured patients have yet to be determined.

Methods

FAST examinations were performed on patients with precordial or transthoracic wounds or blunt abdominal trauma. Patients with a positive ultrasound (US) examination for hemopericardium underwent immediate surgery, whereas those with a positive US for hemoperitoneum underwent a computed tomography scan (if they were hemodynamically stable) or immediate celiotomy (if they were hemodynamically unstable—blood pressure ≤ 90 mmHg).

Results

FAST examinations were performed in 1540 patients (1227 with blunt injuries, 313 with penetrating injuries). There were 1440 true-negative results, 80 true-positive results, 16 false-negative results, and 4 false-positive results; the sensitivity was 83.3%, the specificity 99.7%. US was most sensitive and specific for the evaluation of patients with precordial or transthoracic wounds (sensitivity 100%, specificity 99.3%) and hypotensive patients with blunt abdominal trauma (sensitivity 100%, specificity 100%).

Conclusions

US should be the initial diagnostic modality for the evaluation of patients with precordial wounds and blunt truncal injuries because it is rapid and accurate. Because of the high sensitivity and specificity of US in the evaluation of patients with precordial wounds and hypotensive patients with blunt torso trauma, immediate surgical intervention is justified when those patients have a positive US examination.

Developed for the evaluation of injured patients, the Focused Assessment for the Sonographic examination of the Trauma patient (FAST) is a rapid diagnostic test for assessing patients with potential truncal injuries. The FAST sequentially surveys for the presence of blood in the pericardial sac and dependent abdominal regions, including the right upper quadrant, the left upper quadrant, and the pelvis.[1,2] Although this focused examination is rapidly becoming an accepted practice in many trauma centers in North America,[1–5] the clinical conditions in which it is most accurate in the assessment and management of injured patients have yet to be determined.

We hypothesized that the FAST was most accurate in the assessment and management of patients with precordial or transthoracic wounds and hypotensive patients with blunt abdominal trauma. The objectives of this study were twofold: to determine the accuracy of the FAST when per-

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formed by attending surgeons, trauma fellows, and senior surgical residents on the trauma team during the first 3 years after the technique was introduced in a regional trauma center, and to determine the clinical conditions in which the FAST would be most accurate in the assessment and management of injured patients.

METHODS

Over a 3-year period, the FAST was prospectively analyzed as the primary modality for the evaluation of patients with potential torso injuries admitted to an urban level I trauma center. To be entered into the study, adult patients had to have a precordial wound or blunt torso injury, a physical examination, and the need for a diagnostic modality or test for complete assessment. Only inpatients with a minimum of 23 hours of observation were included in the study. Patients who presented *in extremis* with an unobtainable blood pressure and an indication for an emergent surgical procedure were excluded from the study.

Training

Surgeons completed an ultrasound (US) training course conducted by an experienced surgeon–sonographer. The course content included didactics, videotapes, and practice sessions on patients with normal and abnormal findings, including benign pericardial effusions and ascites. The course participants passed a written test and became eligible to perform the FAST in the clinical setting with supervision during their initial 50 examinations.

Technique

The US examinations were performed with a portable Panther Ultrasound Scanner Type 2002 (B&K Medical, North Billerica, MA) located in the trauma resuscitation room. It was equipped with a variable-frequency transducer (3 to 5 MHz), a hard copy printer, and a video recorder.

Surgeons performed the FAST during the secondary survey of the American College of Surgeons Advanced Trauma Life Support Course while the patient remained in the supine position. A nasogastric tube was inserted if needed, but the urinary catheter was withheld so that the distended bladder would provide an acoustic window to the pelvic structures. US transmission gel was applied to the four areas and the examination was conducted in the following sequence:

1. Pericardial area
2. Right upper quadrant
3. Left upper quadrant
4. Pelvis (Fig. 1).

The transducer was oriented for sagittal sections, placed in the subxiphoid area, and directed toward the patient's left shoulder. The heart was identified and the gain setting was adjusted, if needed, to ensure that blood within the heart appeared echolucent. The view of the heart was obtained and the pericardial region was examined for blood (Fig. 2). The transducer was placed in the right anterior midaxillary line between the 11th and 12th ribs to identify the liver, kidney, and diaphragm in the sagittal sections (Fig. 3A) and to seek blood in Morison's pouch and in the subdiaphragmatic space (Fig. 3B). With the transducer positioned in the left posterior axillary line between the 9th and 10th ribs, the spleen and kidney were visualized and blood was sought in the splenorenal recess and subphrenic space (Fig. 4). The transducer was then directed for coronal sections, was placed 4 cm superior to the symphysis pubis, and was moved inferiorly to demonstrate the full bladder and both sides of the pelvis (Fig. 5).

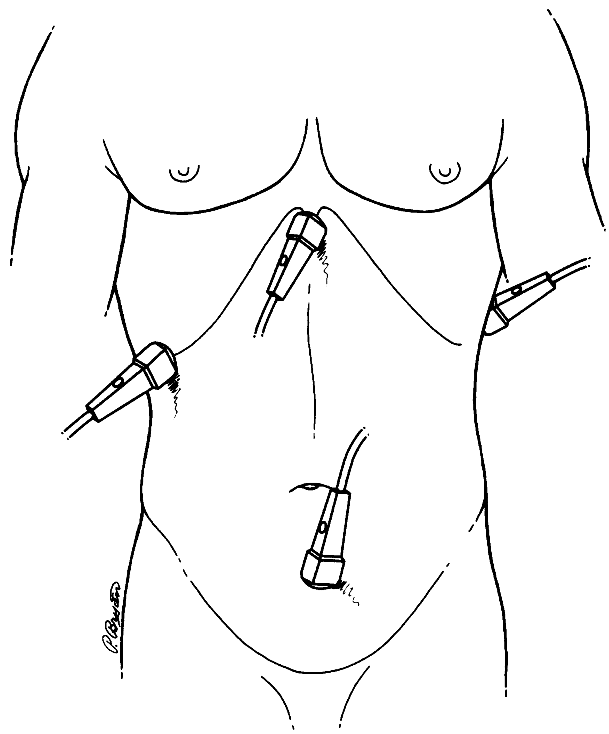

Figure 1. Transducer positions for FAST: (1) pericardial area, (2) right and (3) left upper quadrants, and (4) pelvis.

The automatically timed and dated images were retained for documentation and reviewed by the principal investigator, who commented on the accuracy of the reading and the quality of the image. A good-quality US view was defined as one that demonstrated the correctly imaged section of the body region so that the presence or absence of fluid (blood) could be determined.

Protocol: Patients With Precordial or Transthoracic Wounds

If the US examination found no hemopericardium, the asymptomatic patient was admitted for observation, and serial physical examinations were performed. Patients with positive US examinations underwent immediate sur-

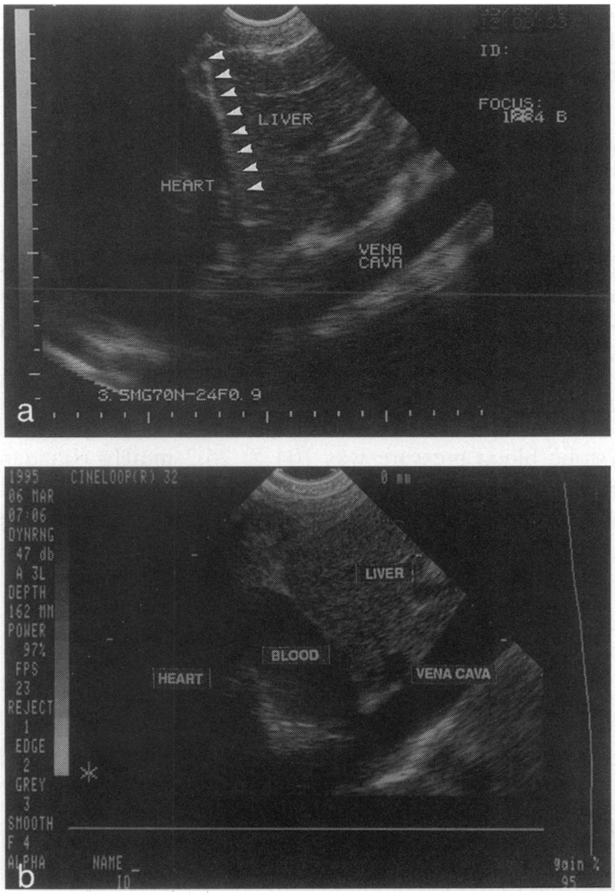

Figure 2. (a) Sagittal view of the heart showing pericardium as a single echogenic (white) line (arrows). Normal findings. (b) Sagittal view of heart showing separation of pericardial layers by blood.

gical intervention, and those findings were recorded. If a good-quality US image could not be obtained or if the reading was equivocal, a subxiphoid pericardial window or a complete echocardiographic examination was performed (Fig. 6).

Protocol: Patients With Blunt Abdominal Trauma

If the abdominal US examination detected no fluid (blood), serial physical examinations were performed and the results were recorded.

If the FAST demonstrated fluid (blood) in a patient who was hemodynamically stable, a computed tomography (CT) scan of the abdomen was obtained to determine if there was solid organ injury and, if so, whether the patient was a candidate for nonsurgical management.

For patients who were hemodynamically unstable and had fluid (blood) demonstrated on the FAST, an emergent celiotomy was performed and surgical findings were recorded (Fig. 7).

If a good-quality image could not be achieved, the team followed the protocol to perform a diagnostic peritoneal lavage (DPL) or CT scan of the abdomen. Based on our previous work,[1,2] if the patient had clinical findings of a seat belt sign across the abdominal region, hematuria, pelvic or spine fracture (thoracic or lumbar), or persistent abdominal pain, a DPL or CT scan was performed.

The results of the pericardial US examinations were categorized as:

- True-positive: Fluid (blood) identified on the US image and surgery that confirmed pericardial tamponade and cardiac injury
- True-negative: Absence of fluid (blood) on the US examination and a continued negative physical examination
- False-positive: Fluid (blood) identified on the US image but a negative exploration (*i.e.*, no injury or blood identified)
- False-negative: Absence of fluid (blood) on the US image, but therapeutic exploration required—that is, injury that required repair.

The results of the abdominal US examinations for all patients were categorized as:

- True-positive: Fluid (blood) noted on the FAST and positive findings on CT scan, DPL, or at surgery

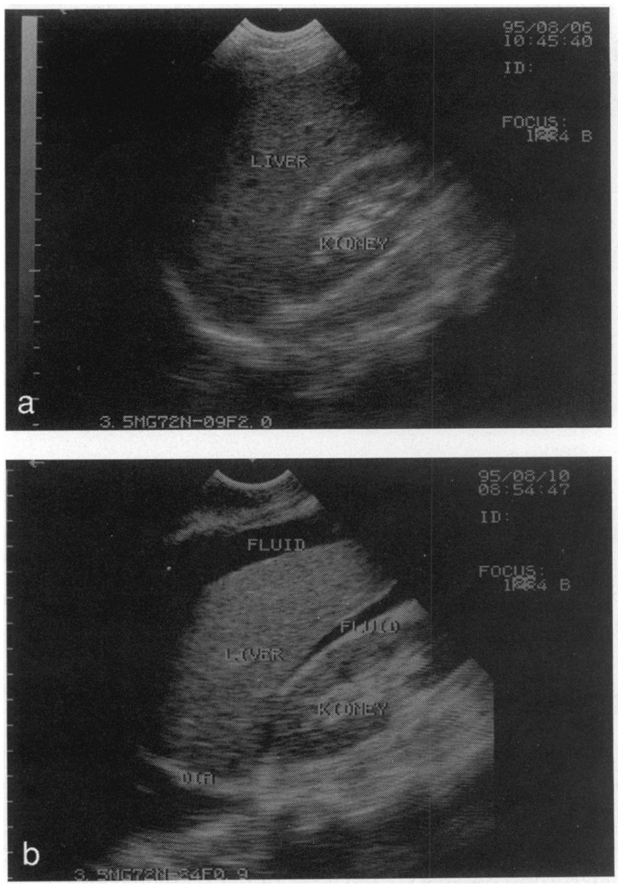

Figure 3. (a) Sagittal section of liver, kidney, and diaphragm. Normal findings. (b) Sagittal section of right upper quadrant showing blood between the liver and kidney and between the liver and diaphragm.

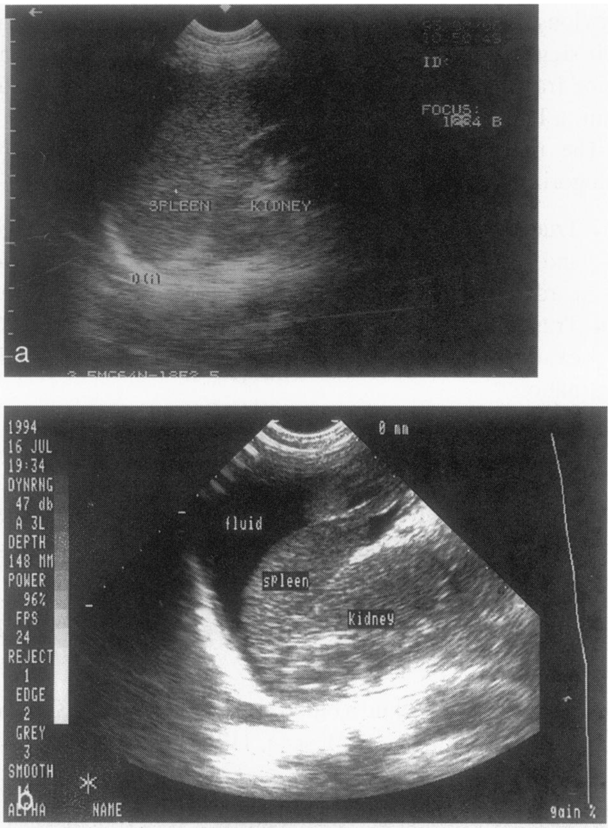

Figure 4. (a) Sagittal section of spleen and kidney. Normal findings. (b) Sagittal section of left upper quadrant showing blood between the spleen and kidney and in the subphrenic space.

- True-negative: Absence of fluid (blood) on the FAST and a negative CT scan, DPL, or continued negative examination
- False-positive: Presence of fluid (blood) on the FAST but negative findings on the CT scan, DPL, or at surgery
- False-negative: Absence of fluid (blood) on the FAST and positive findings on the CT scan, DPL, or at surgery.

Admission blood pressure, demographic data, results of the diagnostic tests (FAST, CT scan, and DPL), surgical findings, and patient outcomes were entered into the US registry. Patients were followed through discharge and as outpatients in the surgery clinic.

RESULTS

During a 3-year period ending November 1997, 1540 patients (1227 with blunt abdominal injuries, 313 with precordial or transthoracic wounds) had FAST examinations by surgeon–sonographers. The mean age was 33 ± 0.3 years (range 15 to 84 years), and 73% of the patients were males.

There were 1440 true-negative, 80 true-positive, 16 false-negative, and 4 false-positive US examinations, resulting in a sensitivity of 83.3% and a specificity of 99.7%. Results for the patients with precordial or transthoracic wounds and blunt abdominal injuries (normotensive and hypotensive) are shown in Table 1.

Patients With Precordial or Transthoracic Wounds

Precordial or transthoracic wounds were present in 313 patients, 289 of whom had true-negative pericardial US examinations and no adverse cardiovascular events. There were no false-negative pericardial US examinations; sensitivity and specificity were 100% and 99.3%, respectively.

True-positive examinations occurred in 22 patients (13 stab wounds, 9 gunshot wounds). The mean admission systolic blood pressure was 104 ± 25.2 mmHg (standard error of the mean), and all patients survived. Surgical findings included wounds to the right ventricle (n = 12), left ventricle (n = 4), right atrium (n = 1), multiple cardiac chambers (n = 2) right atrium/superior vena cava (n = 1), right atrium/inferior vena cava (n = 1), and ascending aorta (n = 1).

The two patients with false-positive pericardial US examinations underwent left thoracotomies for resection and/or repair of their grades IV and V lung injuries. One

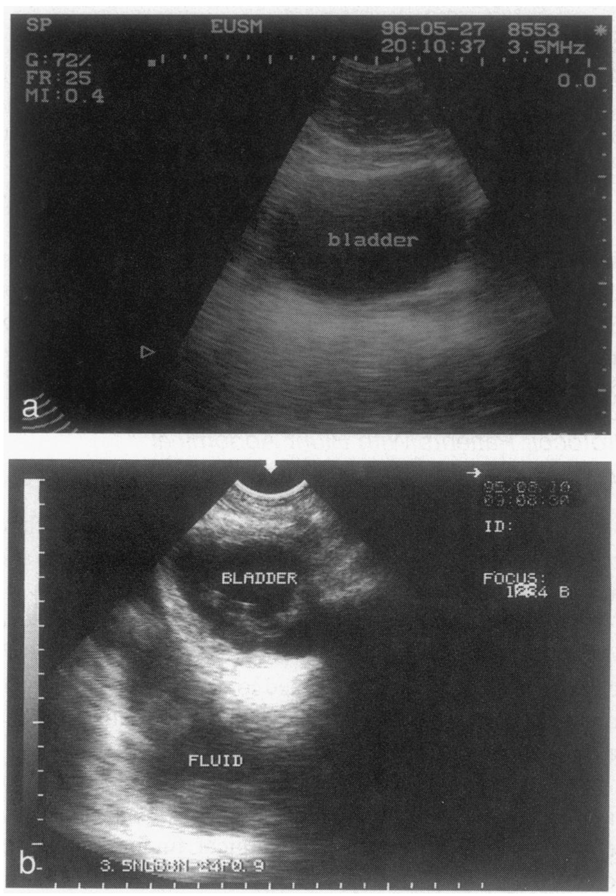

Figure 5. (a) Coronal section of the pelvis showing the full bladder. Normal findings. (b) Coronal section of the pelvis showing the full bladder surrounded by blood.

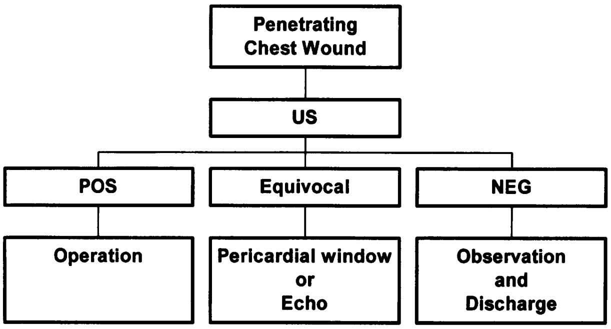

Figure 6. Use of US in the evaluation of a patient with a precordial wound. (Reprinted with permission from J Trauma 1996; 40:1–4)

patient also underwent a subxiphoid pericardial window, which showed normal findings.

Patients With Blunt Abdominal Trauma

Blunt abdominal trauma occurred in 1227 patients; 1197 were normotensive on admission and 30 were hypotensive (systolic blood pressure ≤ 90 mmHg). In the 1197 patients who were normotensive on admission, there were 1129 true-negative, 50 true-positive, 16 false-negative, and 2 false-positive US examinations, for a sensitivity of 75.7% and a specificity of 99.8%. In the 30 patients who were hypotensive on admission, there were 22 true-negative, 8 true-positive, 0 false-negative, and 0 false-positive US examinations, for a sensitivity and specificity of 100%.

Sixteen patients, all normotensive on admission, had false-negative US examinations (Table 2). There were no missed injuries, however, because the patients had clinical findings that warranted the performance of an additional test such as DPL or CT scan per protocol. The reasons for performing either test when the FAST was negative were persistent abdominal pain (n = 7), sudden hypotension (n = 3), hematuria (n = 2), pelvic fracture (n = 2), unexplained tachycardia (n = 1), and unexplained acidosis (n = 1). Four of the 16 patients underwent nonsurgical management of their solid organ injuries, whereas the remaining 12 patients underwent therapeutic surgical procedures. Only 1 of the 16 patients died.

True-positive US examinations were present in 58 patients (50 in the normotensive group and 8 in the hypotensive group). Of the 50 patients who were normotensive on admission, 33 had isolated solid organ injuries; 24 of these patients were treated nonoperatively with success. In the eight patients who were hypotensive on admission and had true-positive US results, seven had therapeutic surgical procedures; the other patient's injuries were confirmed at postmortem examination (Table 3).

Two patients, both normotensive on admission, had false-positive US examinations. One patient with a closed head injury suddenly became hypotensive and underwent an emergent exploratory celiotomy, which showed ileal and cecal contusions that did not require repair. Per protocol, the other patient had a CT scan that was normal, and his hospital course was uneventful.

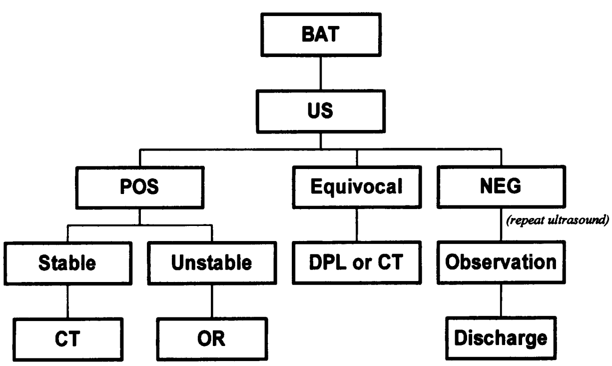

Figure 7. Use of US in the evaluation of a patient with blunt abdominal trauma. (Reprinted with permission from J Trauma 1996; 40:1–4)

DISCUSSION

As a noninvasive examination, the FAST is quickly becoming a frequently used test to assess the injured patient in many trauma centers in North America.[1,2,4–9] Its importance as a diagnostic modality as used by the surgeon, however, will ultimately depend on the areas where it has the greatest impact on the assessment and the management of patients. Examination of data on large numbers of patients such as those in this study, including patients with precordial wounds, provides essential information that clarifies the role of the FAST in the management of the traumatized patient.

Pericardial Ultrasound

Most of the patients with precordial or transthoracic wounds had true-negative pericardial US examinations, a finding that underscores the value of US as a noninvasive screening tool. Although the subxiphoid pericardial window is accurate for the detection of cardiac injury,[10] it is an invasive procedure and may not be indicated in patients in

Table 1. ULTRASOUND RESULTS OF TOTAL PATIENT POPULATION

Specific Groups	FP	FN	Sensitivity (%)	Specificity (%)
Precordial/transthoracic (313)	2	0	100	99.3
Blunt abdominal (1227)	2	16	78.3	99.8
Normotensive (1197)	2	16	75.7	99.8
Hypotensive (30)	0	0	100	100

Total = 1540 patients.
FP = False positive.
FN = False negative.

Table 2. PATIENTS WITH BLUNT ABDOMINAL TRAUMA AND FALSE NEGATIVE ULTRASOUND RESULTS

Patient	*Test (reason obtained)	Diagnosis	Management	Survive
1. TD	CT (abdominal pain)	Liver (grade II) LeForte I fracture Radius fracture	Hepatorraphy	yes
2. WF	DPL (hypotension)	Liver (grade IV)	Hepatorraphy	yes
3. GW	CT (abdominal pain)	Spleen (grade IV)	Splenectomy	yes
4. AP	CT (gross hematuria)	Pelvic fracture Bladder rupture (grade III)	Nonoperative management	yes
5. BC	CT (pelvic fracture)	Liver (grade IV) Abdominal vascular (grade IV) Pelvic fracture	Packing of abdomen	no
6. MP	−DPL (persistent abdominal pain)	Spleen (grade II) Rib fractures	Nonoperative management	yes
7. MS	CT (unexplained tachycardia)	Spleen (grade III) Severe CHI Pulmonary contusion	Splenectomy	yes
8. CG	CT (pain) ↓ Repeat US+ (5 hours) (hypotension)	Small bowel (grade V)	Resection of portion of small bowel with end to end anastomosis.	yes
9. YH	Repeat US+ (20 min)→DPL (acidosis)	Small bowel (grade IV) Bilateral Guistilo III C extremity fractures	Resection of portion of small bowel with end to end anastomosis.	yes
10. KW	CT (abdominal pain)	Liver (grade IV) Rib and scapula fractures Pulmonary contusion	Nonoperative management	yes
11. FC	CT (abdominal pain, pelvic fracture)	Liver (grade III) Pancreas (grade III) Pelvic fracture Rib Fractures	Hepatorraphy	yes
12. JK	DPL (abdominal pain)	Small bowel (grade IV)	Resection of portion of small bowel with end to end anastomosis.	yes
13. TD	CT (abdominal pain) Repeat US−	Liver (grade III) LeForte I fracture Colles fracture	Hepatorraphy	yes
14. LF	DPL (hypotension)	Abdominal vascular (grade I) Liver (grade I) Severe CHI	Ligation of ovarian vein	yes
15. CT	CT (hematuria)	Small bowel (grade IV) Bladder rupture (grade IV) Pelvic fracture	Resection of portion of small bowel with end to end anastomosis. Cystorraphy	yes
16. CC	CT (abdominal pain) Repeat US+ (2 hours)	Spleen (grade III)	Nonoperative management	yes

* Test performed after initial US was negative.
− = negative.
\+ = positive.
CT = computed tomography; DPL = diagnostic peritoneal lavage; CHI = closed head injury.

whom there is a low suspicion of a cardiac wound. Further, when the pericardial US examination is performed by the surgeon in the resuscitation area, the cardiologist's fee is eliminated. Also, central venous catheters are used less frequently, thereby decreasing the risk of iatrogenic complications.

The subcostal image is usually not difficult to obtain, but a severe thoracic injury, a narrow subcostal area, subcutaneous emphysema, or morbid obesity can preclude a satisfactory examination.[11,12] The latter conditions are associated with poor imaging because air and fat reflect the sound beam too strongly, preventing penetration into the target organ. The surgical team was unable to obtain an adequate pericardial US in two patients. One patient had a pericardial window and the other had a complete echocardiographic examination; both tests showed normal findings. Although a special cardiac access transducer or transesophageal echocardiography[13] may have improved cardiac imaging in these two patients, such a modality is not indicated in most patients with these wounds.

Table 3. HYPOTENSIVE PATIENTS WITH BLUNT ABDOMINAL TRAUMA AND TRUE POSITIVE ULTRASOUND

Patient	Systolic BP (mm Hg)	Diagnosis	Management	Survive
*1. CJ	58	Liver (grade II) CHI Bilateral Guistilo III C fractures	Died of head injury soon after admission	no
2. JT	90	Spleen (grade IV) Liver (grade II)	Splenectomy Hepatorraphy	yes
3. BM	85	Liver (grade IV) Fractures (Guistilo III C extremity)	Packing of liver External fixator of pelvis	no
4. DH	69	Spleen (grade IV)	Splenectomy	yes
5. LK	90	Heart (grade IV), CHI Liver (grade IV)	Cardiorraphy Packing of liver	no
6. CH	80	Liver (grade III)	Hepatorraphy	yes
7. MW	80	Liver (grade V) Abdominal vascular (grade III)	Atrial-caval shunt	no
8. CC	80	Aorta (grade IV) CHI Spleen (grade III)	Splenectomy Aortic repair	yes

* Injuries confirmed at autopsy.
CHI = closed head injury.

A more important use of pericardial US by the surgeon, however, is for the early detection of hemopericardium in patients who have a penetrating precordial wound but no overt signs of pericardial tamponade.[7] Ten (45.4%) of the 22 patients with true-positive pericardial US examinations had systolic blood pressures on admission of ≥110 mmHg. Based on these admission blood pressures, it is unlikely that the presence of cardiac wounds would have been strongly suspected. Although these patients eventually become symptomatic, it is likely that an earlier diagnosis of hemopericardium prevented the physiologic deterioration and contributed to improved patient survival.

The two patients in the study with false-positive pericardial US examinations had associated massive left hemothoraces with the presence of mediastinal blood. Although Meyer et al.[14] cautioned that a false-negative pericardial US may occur because a large hemothorax may obscure a small hemopericardium, our data could indicate that a massive hemothorax may surround the pericardium and produce a false-positive result. Based on this experience, we routinely repeat the pericardial US examination after a tube thoracostomy is performed for the evacuation of a large hemothorax.

Abdominal Ultrasound

As expected, the majority (93.8%) of the patients with blunt abdominal trauma had true-negative US examination results, indicating that hemoperitoneum is not common in patients with a blunt mechanism of injury. This finding supports the use of US as the initial diagnostic modality to evaluate injured patients rather than the routine use of an invasive DPL or a costly CT scan.

Successful nonoperative management was achieved in 24 (48%) of the 50 patients who were normotensive on admission and had true-positive US examinations. These results justified obtaining a CT scan of the abdomen rather than immediately performing an exploratory celiotomy.[2]

In this study, US was especially useful to the surgeon for the evaluation of hypotensive patients. Its high accuracy for identifying intraabdominal hemorrhage as a cause of hypotension justified emergent celiotomy. Seven of eight patients with true-positive US examinations underwent therapeutic surgical procedures; the other patient died of his severe closed head injury (before celiotomy could be performed), and hemoperitoneum and intraabdominal injuries were noted at the postmortem examination. Further, the value of the FAST for the assessment of hypotensive patients was underscored in the 22 patients who were hypotensive on admission but had a negative FAST examination. In these patients, intraabdominal hemorrhage was rapidly excluded as the cause of hypotension, and the surgeons' efforts were directed toward other potential causes.

The 16 false-negative and 2 false-positive US examination results were reviewed to determine whether they could have been avoided. With the exception of one patient whose urinary bladder was not full, the hard copies of the US images were of good quality. Other issues that surfaced as possible explanations included the performance of repeated examinations, the experience of the examiner, and the use of videotapes to obtain the entire US examination.

Four patients with false-negative results had repeated studies. Two converted to positive, 20 minutes and 5 hours after their initial US examinations were performed. Similar results were previously reported in which repeated US examinations were routinely performed within 12 to 24 hours of the patient's admission.[2] Another explanation for the initial negative findings may be that the US examination was performed so soon after injury that hemorrhage was not yet significant enough to give a positive result. Bode et al.[15] cited this as a potential explanation for their false-negative results. Whereas some authors recommend frequent repeat examinations,[16,17] this did not seem practical for our busy trauma service. Other prospective studies should be performed to define the interval for and utility of repeat US examinations. Nonetheless, emphasis should be placed on the performance of repeated physical examinations and the observation of other parameters, such as serial hematocrit values, so that decisions regarding patient management are based on the entire clinical picture rather than on US alone.

In other studies that have examined the use of US in the trauma setting, the learning curve had an impact on the sensitivity and specificity of the results.[2,6,16,18] In this study, however, its impact on the results was believed to be less of an issue because the hard copy US images were deemed to be of good quality and the training course focused on the pitfalls of imaging that were found to be problems for surgeons in the clinical setting. For example, the surgeons learned to perform and interpret examinations in patients with minimal as well as large amounts of ascites so that differences in the spectrum of a positive FAST could be noted.

Videotaping the US studies would have provided the entire examination in real-time imaging, therefore giving more information about the false-positive and false-negative examinations. Although advantageous, routine videotaping may not be practical when a large number of injured patients must be evaluated.

Further review of the false-negative data failed to show that any particular injury was consistently missed on US. Instead of attempting to delineate the areas in which US is not consistently accurate, clinicians should exercise the same clinical judgment when using US that they use with other diagnostic modalities.

Only one of the two patients who had false-positive results underwent exploratory celiotomy. That patient was found to have minor ileal and cecal contusions that required no treatment. At the time, however, surgical intervention was justified because the US examination was presumed to be positive and the patient suddenly became hypotensive. Protocol was followed for the other patient who supposedly had a positive US examination; in this patient, a CT scan of the abdomen showed normal findings. Both cases underscore the importance of using sound clinical judgment and coordinating the results of a diagnostic test with the clinical picture.

Potential deficiencies of this study included the lack of follow-up of all patients after discharge and the nonconsecutive study population. Although only approximately 50% of injured patients return to our surgery clinic, Grady Memorial Hospital is the only level I trauma center in Atlanta, GA, and patients with prior treatment for injuries most commonly return if a complication develops. All patients in this study were observed for a minimum of 23 hours so that any adverse thoracoabdominal events could be diagnosed. To our knowledge, no injury was missed. Also, the patients in this study were a nonconsecutive sample because not all of our surgeons were skilled in US techniques, and images were difficult to obtain in some patients. Hence, the data may be biased, but they do represent our trauma patient population.

Notwithstanding those issues, US has been found to be a user-friendly modality that is especially applicable to the acute setting because of its unique qualities: it is noninvasive, rapid, portable, repeatable, and cost-effective. It requires minimal patient preparation and is associated with a high degree of patient compliance because it is virtually painless.

Since the preliminary report of surgeons in the United States using US to diagnose traumatic hemoperitoneum,[6] larger studies have been published that lend credence to the ability of surgeons to perform and interpret focused US examinations. Although these studies have validated a new tool as used by surgeons for the assessment of the injured patient, they have generated several concerns as well. Some of these include the quantity of fluid (blood) that can be detected with US,[19] the potential relation of the quantity of fluid (blood) to the need for surgical intervention,[20] injuries that may be missed in the absence of hemoperitoneum,[21] and the validity of the FAST for the evaluation of the injured pediatric patient.[22–24] As with any new modality, more data are needed to answer these questions.

Our experience with US has convinced us of its advantages and has significantly influenced our approach to the injured patient. In our practice, initiation of surgeon-performed US examinations has led to a decrease in the number of DPL and CT scan procedures performed. It has become apparent that the FAST can supplant measurements of central venous pressure for the detection of hemopericardium and can replace DPL for the detection of hemoperitoneum in many injured patients. Although CT scan remains a valuable diagnostic test, its indications for the evaluation of the injured patient have narrowed. Both CT scan and US should be used together, however, when the US examination documents hemoperitoneum in the stable patient.[25,26]

Recently, the American Board of Surgery redefined the scope of surgical practice to include a "working knowledge of ultrasonography of head and neck, breast, abdomen (including laparoscopic intra-abdominal) and endorectal ultrasound."[27] Although the focus of our study is the use of US in trauma patients, experience acquired in this setting can be applied to other areas as well because each technique learned reinforces the surgeon's knowledge of US principles, encourages rapid learning of new US techniques, and extends the surgeon's diagnostic armamentarium.

SUMMARY

Data from this study underscore the conclusion from our previous work that US is a rapid and accurate diagnostic modality for the detection of hemopericardium and hemoperitoneum.[1,2,7] Also, we have once again documented that surgeon–sonographers can effectively use US in this limited diagnostic spectrum as the primary modality for the assessment of injured patients.

From our analysis of 1540 injured patients undergoing FAST examinations by surgeon–sonographers, we reached the following conclusions:

- US should be the initial diagnostic adjunct for the evaluation of patients with precordial wounds and blunt truncal injuries because it is rapid and accurate and augments the surgeon's diagnostic capabilities.
- Surgeon-performed FAST is most accurate when used for the evaluation of patients with precordial or transthoracic wounds and a possible hemopericardium and for the evaluation of patients with blunt torso trauma who are hypotensive.
- Because of the high sensitivity and specificity of US when used to evaluate patients with precordial or transthoracic wounds and hypotensive patients with blunt torso trauma, immediate surgical intervention is justified when those patients have a positive US examination.

The accuracy of surgeon-performed US in this study strongly supports education in this technique for both residents and practicing surgeons. We recommend that surgeons become proficient in using this specific technique and that general surgery program directors incorporate focused US instruction into the training of residents in general surgery.

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Discussion

Dr. Olga Jonasson (Chicago, Illinois): In the hands of Dr. Rozycki's team, portable, modern diagnostic ultrasound equipment has proved to be a rapid, reliable, and economical shortcut in the evaluation of patients with abdominal and thoracic trauma. These results were not achieved with the old method of "see one,